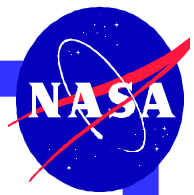# Air-Ground Integration Experiment (AGIE)

**FAA William J. Hughes Technical Center**
**NASA Ames Research Center**
**Volpe National Transportation Systems Center**

**Randy Sollenberger, FAA ACT-530**
**Paddy Cashion, SJSU/NASA Ames Research Center**
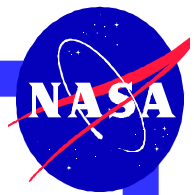
# Research Team & Sponsors

- **Inter-Agency Working Group**
  - FAA WJH Technical Center, ACT-530/540
  - NASA Ames Research Center
  - Volpe National Transportation Systems Center
- **Sponsors**
  - FAA (AAR-100, ASD-130, ATP-400)
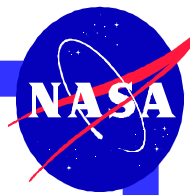  - NASA Ames Research Center (Advanced Air Transportation Technologies Program)

# Project Goals

- **Identify operational issues that affect shared-separation operations**

- **Provide recommendations for information requirements and procedures**

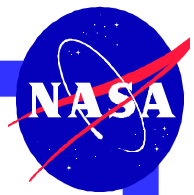- **Evaluate controller and pilot workload and situational awareness**

# General Approach

- **Real-Time Human-in-the-Loop Simulation**

- **FAA WJH Technical Center**
  - Interoperability and Integration Facility ($I^2F$)
    - Display System Replacement (DSR) Workstations
  - User Request Evaluation Tool (URET)

- **NASA Ames Research Center**
  - Crew Vehicle System Research Facility (CVSRF)
    - Boeing 747-400 Simulator
  - Cockpit Display of Traffic Information (CDTI) with Airborne Alerting Logic (AL)

# Methods

- **Participants – 4 Weeks of Simulation**
  - 2 Controller Teams (R-Side/D-Side) each week
    - 12 Memphis ARTCC FPLs
    - 4 Memphis ARTCC Supervisors
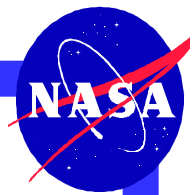  - 1 Flight Crew (Pilot/Co-Pilot) each week

- **Airspace – Memphis ARTCC**
  - High-Altitude Sectors 21 and 44

- **Experimental Design**
  - 4 Different Control Conditions (Scenarios)
  - Each Scenario 90-Minutes in Duration
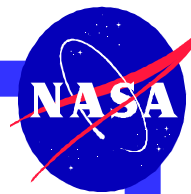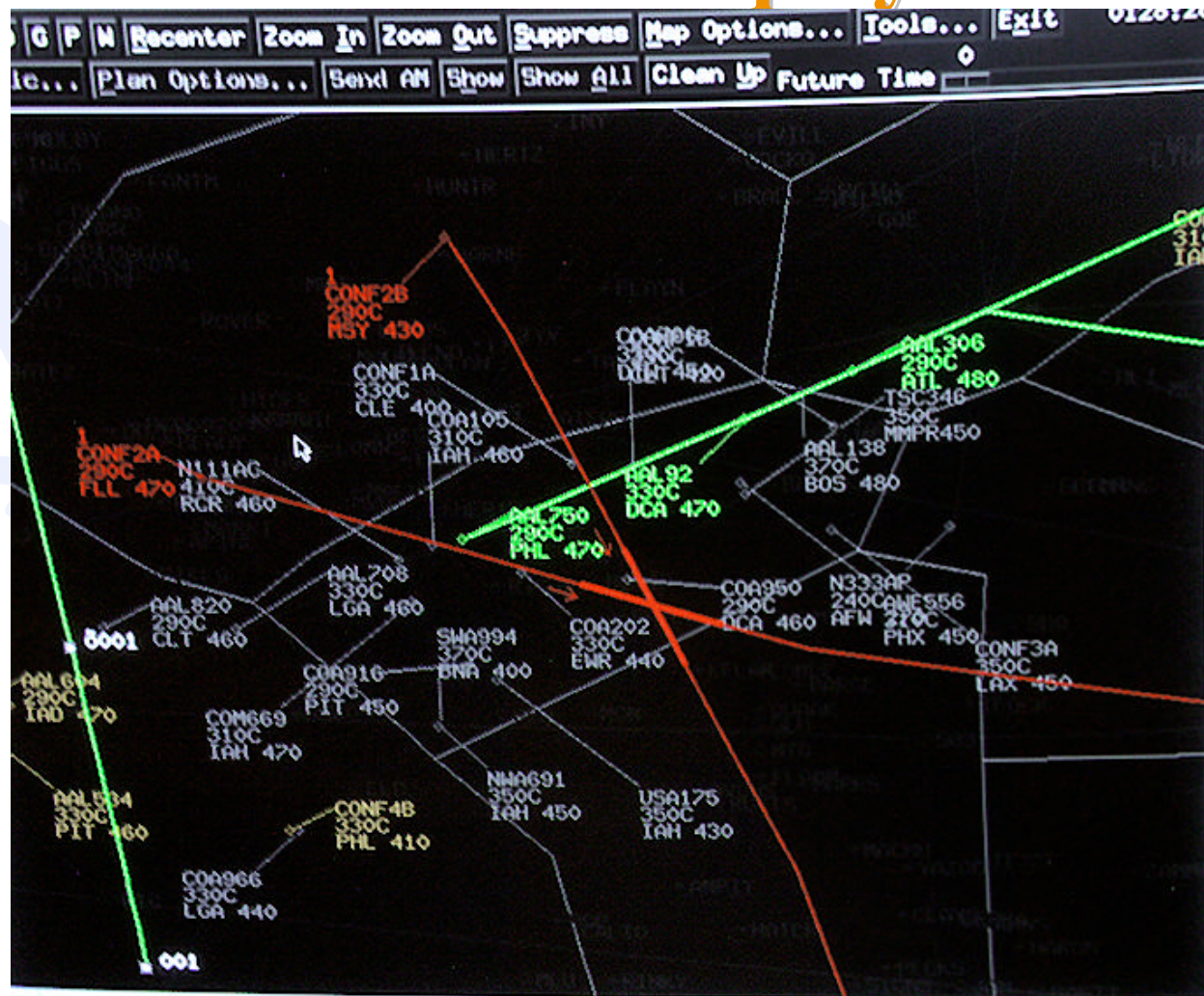    - B747-400 simulator completed 3 flights per scenario
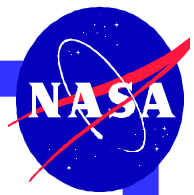
# Experimental Conditions

- **Baseline: URET only**
  - ATC Full-Separation Environment
- **Locus of Control 1: URET and CDTI/AL**
  - ATC Full-Separation Environment
- **Locus of Control 2: URET and CDTI/AL**
  - Shared-Separation Environment / ATC Informed
- **Locus of Control 3: URET and CDTI/AL**
  - Shared-Separation Environment / ATC Not Informed
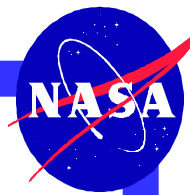
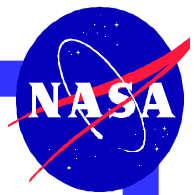# URET Display

# Scenarios Characteristics

- **Traffic on flight deck CDTI (ADS-B range 120 nm) and a 4100' altitude filter**

- **Traffic on controller's radar display (DSR with URET)**

- **Moderate/High traffic density**

- **Adjoining sectors in Memphis ARTCC to investigate operational issues pertaining to inter-sector coordination**
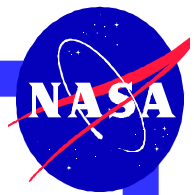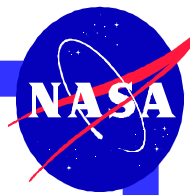
# Flight Deck Display – No Alerts

# Flight Deck Display – Alert Status

# Preliminary Results - Flight Crews
## (Based on data from three flight crews)

- **In Locus 2, controllers canceled free flight 5 out of 9 flight scenarios**
  - No flight crew cancellations

- **No flight crew separation losses**

- **Crews seemed to prefer the use of heading maneuvers for resolution of these conflicts**

- **Based on self-report data, crews stated they monitored the cockpit display 63-68% of the time**

- **Flight crews felt that the CDTI was cluttered and recommended filtering based on altitude**
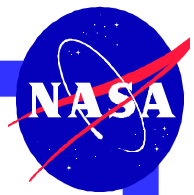
# Preliminary Results - Controllers

- **Controllers rated their workload higher in Locus 2 compared to Baseline, Locus 1, and Locus 3**

- **Controllers rated the level of safety for the procedures as lower in Locus 2 and Locus 3 compared to Baseline and Locus 1**

- **Controllers were concerned that pilots allowed conflicting aircraft to track closer than controllers normally allow**
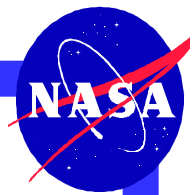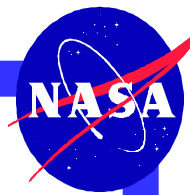
# Summary

- **Complex, high fidelity simulation testbed was collaboratively established between FAA and NASA**

- **Concerns about shared-separation procedures were identified from both air and ground perspective which can guide future development of procedures and equipment**

- **Lessons learned from AGIE establish foundation for future collaborative research between FAA and NASA**
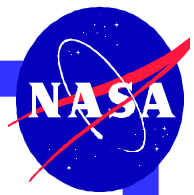
# Flight Deck Display - Predictors

# Data Collection

- **Timing Data**
  - Conflict Detection, Communication, and Maneuver Times

- **Communications**
  - Number, Duration, Type, and with Whom

- **Number of Conflict Alerts**

- **Closest Point of Approach**

- **Deviation from Path/Cost of Maneuver**

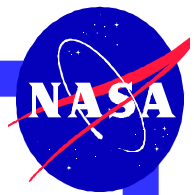- **Procedures/Conflict Avoidance Maneuvers**

# Data Collection (continued)

- **SAR, URET, and CDTI Data**
- **Subject Matter Expert Observations**
- **Controller Workload Ratings**
- **Questionnaires and Debriefings**
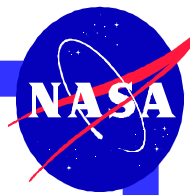- **Audio-Video Recordings**

# Technical Accomplishments

- **High Fidelity Air-Ground Integrated Simulation with State-of-the-Art Equipment**
  - DSR Workstations with URET Conflict Probe
  - Full Motion Boeing 747-400 Simulator with CDTI/AL Conflict Probe

- **Two-way Data Transfer between FAATC and NASA Ames**
  - DSR workstations display B747 data from NASA
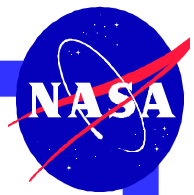  - CDTI/AL display other target data from FAATC

# Future Research Possibilities

- **Mixed Equipage**

- **Transitioning Airspace**

- **Addition of Multiple Carriers**
  - Negotiations
  - Competition Issues

- **Inclusion of Airspace Constraints**
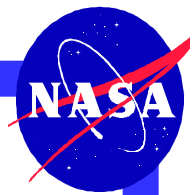  - Weather
  - Special Use Airspace

# NASA's Previous Research

- **Two studies examined self-separation from flight deck perspective assuming new procedures and technologies**

- **Third study examined flight crews and ATCS in shared-separation environment**

- **Ground conflict probe not employed**

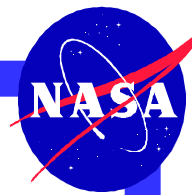- **Issues studied included traffic density and aircraft convergence angles**

# Flight Deck Display (CDTI) Features

- **Available on the B747-400 Navigation Displays**

- **Assumes ADS-B range of 120 nm for surveillance**

- **Airborne alerting logic (velocity vector)**

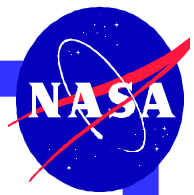- **TCAS II is also available to flight crews**

# Flight Deck Display (CDTI) Features (continued)

- **Altitude and Airspeed displayed for all aircraft within range**

- **Navigation display range pilot selectable**

- **Call sign for aircraft pilot selectable**

# FAA's Previous Research

- **Three studies examined controller workload and situational awareness in shared-separation environment**

- **Two or three simulation pilots moved all radar targets according to pre-defined scripts**

- **Aircraft simulators were not employed**

- **Issues studied included different levels of shared-separation and supporting ground automation**